3.4 Low-Frequency Noise

3.4.1 Existing Conditions

3.4.1.1 Background Information on Low-Frequency Noise

It has long been recognized that gas turbine power plants can cause a variety of noise impacts to the surrounding community (Newman & McEwan 1979). The types of power plant noise that can cause community annoyance include the following:

Broad-Band Noise

This is the overall sound level under conditions when no specific frequency ranges are readily discernible. Broad-band noise is typically measured as A-weighted decibels (dBA). Broad-band noise is regulated in Whatcom County and SE2 performed predictive modeling as part of the Second Revised ASC to demonstrate compliance with the County's noise ordinance.

Low-Frequency Noise

This is characterized by noise levels at frequencies less than about 100 hertz (Hz). For this SEIS, low-frequency noise is described as noise levels in the 16 Hz, 32 Hz, and 64 Hz octave bands. Noise at those frequencies can be annoying to some people even at relatively low levels that might not be discernible to other people standing nearby (van den Berg 1998). Low-frequency noise can propagate through closed windows and lightweight walls typical of most homes, so in many cases the indoor and outdoor levels at homes near sources of low-frequency noise can be nearly identical. For that reason, annoyance from low-frequency noise usually occurs when the receiver is indoors where the background noise levels are low compared to the intruding low-frequency noise. If the low-frequency noise level is sufficiently high, it can cause discernable vibration and rattling of windows or other lightweight structures.

Tonal Noise

Noise from gas turbines can sometimes cause a "whine" with a distinct tonal quality. These tones can be readily discernible (and therefore be potentially annoying) even when the overall broad-band noise level is low.

Periodic Beats

In some cases where two sources of low-frequency noise operate near each other (e.g., two adjacent turbines operating at the S2GF), sound waves propagating away from the sources can interact to cause repetitive low-frequency "beats." These periodic beats can be readily discernible (and be potentially annoying) even when the overall noise level is low.

3.4.1.2 Regulatory Framework

Current Whatcom County and Washington State noise ordinances regulate only broad-band noise (expressed as dBA). Therefore, there are no quantitative regulatory limits on low-frequency noise, tonal noise, or repetitive beats applicable to the S2GF. However, other regulatory agencies in the region have quantitative limits on these types of noise, which could be used as guidance to assess the impacts of low-frequency noise and tonal noise emitted by the S2GF.

The King County, Washington noise ordinance specifies adjustment factors to reduce the allowable broad-band noise limits (expressed as dBA) if the noise source produces either tonal noise or repetitive, periodic noise. The King County ordinance provides quantitative definitions for the terms "pure tone component" and "periodic sound." If the noise source emits either of those types of annoying noise, then the allowable dBA limits at the receiving property are reduced by 5 dBA.

The State of Oregon noise regulation (OAR 340-035-0035) specifies allowable limits on octave-band noise levels at the receiving property. The allowable limits for the 32 Hz and 64 Hz octave bands are 65 dB and 62 dB, respectively. Oregon also imposes a 5-dBA adjustment factor to allowable broad-band noise limits for cases where the intruding noise is either tonal or repetitive.

3.4.1.3 Existing Low-Frequency Noise Levels

SE2 has not provided EFSEC with measurements of low-frequency noise levels at receivers near the project site. Long-term measurements of A-weighted noise levels were taken at numerous residential receivers as part of SE2's noise impact assessment. However, those previous A-weighted noise level measurements cannot be used to assess existing low-frequency noise levels near the project site.

There are two existing industrial facilities operating near the project site that could contribute to baseline low-frequency noise levels: the existing SE1 gas turbine power plant and a manufacturing plant operating south of the proposed S2GF plant location. Both of those facilities are smaller than the proposed S2GF turbines and are farther from the residential receivers that could be affected by low-frequency noise generated by S2GF.

3.4.2 Environmental Impacts

3.4.2.1 Project-Related Sources of Low-Frequency Noise

Table 3.4-1 lists the sound power levels of the major items at the plant at the low-frequency octave bands of 32Hz and 64 Hz based on information provided by SE2 in the Second Revised ASC. Data for the 16 Hz octave band were not provided by SE2.

The values listed in Table 3.4-1 are sound power level noise emissions at each source. The power levels are estimated values provided to SE2 by the equipment manufacturers. The combined sound power levels emitted by the power plant will produce sound waves that propagate outward and cause sound pressure levels at the distant receivers. Thus, the sound pressure levels at the receivers would differ from the sound power levels listed in the table.

3.4.2.2 Estimated Low-Frequency Noise Levels at Residential Receivers

As part of the Second Revised ASC, SE2 conducted predictive modeling of the A-weighted broadband noise levels at four residential receivers near the S2GF. The noise modeling was done using the Environmental Noise Model (ENM) which accounts for barrier attenuation provided by the tall structures at the project site and for meteorological factors, including wind and temperature inversions. The modeling showed that the predicted A-weighted noise levels caused solely by the S2GF sources (not including background) met both the daytime and nighttime noise limits set by Whatcom County and Washington State noise regulations.

However, SE2 did not provide the results of predictive modeling of the sound levels at the 32 Hz and 64 Hz octave bands. Therefore, at this time it is not possible to determine whether or not the low-frequency noise levels produced by the S2GF would result in an impact or if they would exceed the limits of the State of Oregon's noise ordinance which could be used as guidance for the impact assessment.

Table 3.4-1. Sound Power Levels for Equipment at S2GF (Based on Manufacturer Estimates)

Equipment Item	Sound Power Level (dB) at Listed Octave Band Frequency	
	32 Hz	**64 Hz**
Inlet Filter House No. 1	128	124
Inlet Filter House No. 2	128	124
Turbine No. 1	110	122
Turbine No. 2	110	122
HRSG No. 1	125	119
HRSG No. 2	125	119
Stack No.1 Wall Noise	103	101
Stack No.2 Wall Noise	103	101
Stack No. 1 Exhaust Noise	126	125
Stack No. 2 Exhaust Noise	126	125
Steam Turbine	114	117
Gas Turbine No. 1 Transformer	110	116
Steam Turbine Transformer	113	119
Station Transformer	97	103
Cooling Tower Fan No. 1 Discharge	No data	110
Cooling Tower Fan No. 2 Discharge	No data	110
Cooling Tower Fan No. 3 Discharge	No data	110

3.4.3 Noise Mitigation Measures

The S2GF includes one design feature that reduces low-frequency noise: SE2 states that the use of the heat recovery steam generator (HRSG) downstream of the combustion turbine serves as a silencer for low-frequency noise that might otherwise be associated with a turbine used in a single-cycle configuration. In addition, as part of its Second

Revised ASC, SE2 proposed the following mitigation for low-frequency noise and tonal noise:

> To address additional concerns about noise, SE2 will monitor sound levels before construction and after operation of the S2GF. In addition to monitoring sound metrics related to demonstrating compliance with County and City noise regulations, SE2 will evaluate low-frequency sound and tones. The monitoring shall include a minimum of 12 locations up to a distance of 3.5 miles from the plant. SE2 will select measurement locations in concert with City of Sumas or Whatcom County staff, focusing on residential locations.
>
> Post operational noise measurements shall begin within 2 months of the commencement of operation. If monitoring indicates that the plant is not in compliance with City or County noise regulations or that the S2GF generates low-frequency sounds or tones that City and County noise regulation staff jointly agree are reasonably objectionable, SE2 engineers will investigate the source of the noise and identify one or more means of mitigating the noise. At the end of the S2GF's first operational year, SE2 will submit for the Council's approval a report providing the pre- and post-operation monitoring results and any mitigation plan found to be necessary.
>
> Once post-operational monitoring indicates the plant is in compliance with City and County noise regulations and that there is no reasonably objectionable low-frequency noise or tones, the noise monitoring program will be deemed complete.

The result of this proposed approach is that no mitigation of low-frequency noise problems would occur until after the facility is constructed and operated, and not until one year after operation.

Although SE2 has not proposed specific mitigation measures, it listed potential mitigation measures to address low-frequency noise at the generating facility in a letter to Jones & Stokes (EFSEC's independent environmental consultant), dated August 13, 2001. The letter did not state whether these measures would occur before or after construction. These measures are described below.

3.4.3.1 Potential Noise Reduction Design Measures

These potential mitigation measures could be designed into the project and installed as a part of construction. However, they would be difficult to incorporate after the facility has been constructed. These include:

- Installation of HRSG stack silencers
- Specification of low-frequency noise limits for equipment
- Use of low-noise fans for cooling towers
- Installation of low-noise transformers

- Avoidance of use of centrifugal fans for building ventilation

3.4.3.2 Potential Retrofit Noise Mitigation Measures

Some of the potential mitigation measures identified by SE2 could be applied as retrofits to original equipment after the facility has commenced operation. These include the following:

- Thicker HRSG walls
- Heavier building walls
- Reactive silencers
- Noise barriers or enclosures at outdoor equipment
- Absorptive panels at the bottom of the stacks

SE2 also listed "active noise control" as a potential mitigation. Active noise control uses microphones to detect sound waves emitted by the source and speakers to emit sound waves that match the waves emitted by the source, thereby canceling the sound waves emitted by the source. This technology can be highly effective but it is not applicable to all of the sources at the S2GF. Active noise control is currently commercially available only for simple industrial noise sources such as ventilation ducts handling ambient temperature gas streams. Aircraft engine manufacturers and research institutes are developing active noise control for gas turbines and high-temperature industrial stacks, but these systems are not yet commercially available.

Although the measures listed above were proposed, no analysis of their effectiveness was offered by SE2.

3.4.3.3 Recommended Mitigation Measures

The S2GF includes one design feature that reduces low-frequency noise: SE2 states that the use of the HRSG downstream of the combustion turbine serves as a silencer for low-frequency noise that might otherwise be associated with a turbine used on a single-cycle configuration. In addition, as described previously, there has been considerable research into low-frequency noise. This noise can annoy some people more than others and the occurrence of the annoyance can vary during the course of the day depending on background conditions (van den Berg 1998). Therefore, SE2's proposal to establish an environmental impact criterion for low-frequency noise "that City and County noise regulation staff jointly agree are reasonably objectionable," might not result in levels of low-frequency noise that are acceptable to residents near the S2GF. To minimize potential impacts due to low-frequency noise, SE2 could commit to the following mitigation measures as a part of the certification process.

Establish Quantitative Low-frequency Noise Limits Prior to Construction

Prior to construction of the S2GF, SE2 could research, for council approval, literature and numerical noise limits from other jurisdictions to develop, for council approval, a reasonable criterion for allowable low-frequency noise and pure tones at the nearest residential receivers.

Examples of published information addressing low-level noise limits include the following:

- The American National Standards Institute (ANSI) Bulletin S12.9-1996/Part 4 states "Generally, annoyance is minimal when octave-band sound pressure levels are less than 65 dB at 16 Hz, 32 Hz and 64 Hz midband frequencies."

- The Oregon State noise regulation (OAR 340-035-0035) specifies allowable octave-band nighttime exterior noise levels at residential areas of 65 dB and 62 dB at 32 Hz and 64 Hz, respectively.

- The American Society of Mechanical Engineers document entitled "Low Frequency Gas Turbine Noise" (Newman and McEwan 1979) states that "The criterion now used by the British Gas Corporation when specifying noise control for gas turbines is 60 dB in the 32 Hz octave band at the nearest dwelling."

- Using these examples, the following criteria for low-frequency noise levels at residences near the proposed S2GF could be established:

  32 Hz octave band: 60 to 65 dB

  64 Hz octave band: 62 to 65 dB

However, other criteria may be identified, and a defensible criterion for the 16 Hz octave band would have to be established.

Conduct Predictive Noise Modeling Prior to S2GF Construction

As noted above, SE2 conducted a modeling study to demonstrate that broad-band noise from the plant complied with the County's existing noise limits. A similar modeling study could be conducted to predict low-frequency noise levels prior to the installation of equipment.

Conduct an Impact Analysis and Propose Specific Mitigation Measures

The results of the low-frequency noise modeling could be compared to the low-level noise limits established for the nearest residential receivers. Based on the results of this impact analysis, SE2 could identify specific mitigation measures that would be incorporated into the project if modeling indicated that the desired low-frequency noise

limits would be exceeded. These studies and the proposed mitigation measures could be submitted to EFSEC for review and approval prior to initiation of construction.